Conditional Discrimination With Conceptual Simultaneous and Successive Cues in the Squirrel Monkey (*Saimiri sciureus*)

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At the end of several stages of training, 4 squirrel monkeys met an 87% criterion for choosing correctly between exemplars of the concept "sameness" and the concept "difference," the simultaneous cues, as a function of having been cued by an exemplar either of the concept "triangularity" (cued sameness) or "heptagonality" (cued difference), the successive cues, which were presented in random order. In addition, the best monkey met criterion when the exemplars of sameness and difference were presented 16 s after the withdrawal of the exemplar of triangularity or heptagonality, and the other monkeys performed successfully with shorter delays. The results are discussed in terms of (a) "working memory," (b) the significance for the evolution of behavior of investigating the conceptual capacities of animals, and (c) implications for language in nonhuman animals.

The present investigation is relevant to four topics of considerable contemporary interest. First, the conditional discrimination paradigm is one of long-standing and current interest (Borovski, 1930, cited by Lashley, 1938; Carter & Werner, 1978; Schrier & Thompson, 1980). Second, the *delayed* conditional discrimination paradigm, also used in the present work, is useful for the study of short-term or "working memory" (Honig & Thompson, 1982). Third, the use of a conceptual, symbolic cue to designate the correct one of two conceptual choices has relevance for the study of language in animals (cf. Savage-Rumbaugh, Rumbaugh, Smith, & Lawson, 1980). Fourth, the present study is directly applicable to the study of the evolution of animal intelligence in terms of the approach proposed by Thomas (1980). That approach, which equates levels of intelligence with an eight-level hierarchy of learning abilities, would include the present experiment at level 7.1 (on an ordinal scale).

According to French (1965), the simplest conditional discrimination task has one set of successive and one set of simultaneous discriminanda. One member of the successive set appears on each trial to designate which of the simultaneous discriminanda is correct. In a typical example, two objects (the simultaneous discriminanda) appear on a test tray. If the tray is one color, object A is correct, but if it is another color, object B is correct. Typically, the same two objects and the same two trays are used until a criterion of correct responding has been met. Hereafter, such paradigms are viewed as involving *specific* as opposed to *conceptual* learning. Evidence for conceptual conditional discrimination requires that specific learning be precluded. This may be done by (a) using new stimuli on each trial, (b) using generalization tests with new stimuli, or (c) using enough stimuli to make it unlikely that criterion can be met by learning specific associations.

Riopelle and Copelan (1954) provided evidence that rhesus monkeys could successfully perform a conditional discrimination task when new successive discriminanda were used in a generalization test; specifically, their monkeys learned to change their responses from one object to another when the tray color was changed. Thomas and Kerr (1976) provided evidence

that squirrel monkeys could perform successfully when new simultaneous discriminanda were used on each trial; specifically, exemplars of the concepts of "oddity" and "nonoddity" were used, and white and black trays were used to designate oddity-correct or nonoddity-correct, respectively. The present study may be the first to use conceptual simultaneous *and* successive discriminanda (however, see the following paragraph). In the later stages of training, the successive discriminanda were exemplars of the concepts "triangularity" and "heptagonality," and the simultaneous discriminanda were exemplars of the concepts "sameness" and "difference." Concurrently and in random order, the monkeys were given trials that may be described as "if triangularity, then sameness is correct" and "if heptagonality, then difference is correct."

The question of priority may depend upon one's view of a study by Schusterman and Krieger (1984). They used a set of "gestural signs" (movements of a trainer's arms and hands) to cue sea lions to perform actions (e.g., toss, fetch) on objects. In addition, the gestures included "modifiers" (e.g., toss ball on land, toss ball on water). Whether this study should be considered to involve conceptual simultaneous (the objects and actions to be performed) and successive (the gestures) cues depends on whether one views the sea lions' acquisition to be conceptual or specific as discussed in the second paragraph here. The best performance reported was the acquisition of 20 signs (involving 5 actions, 10 objects, and 5 modifiers) which took 24 months of training to achieve. We suggest that it is possible that specific rather than conceptual associations were learned. Although the study is a significant one, we are compelled to say that it may not be conceptual, at least in the way we believe conceptual should be defined and demonstrated in nonhuman animals.

An additional variable in the present study was the use of time delays between withdrawal of the successive discriminandum (also known as the conditional, symbolic cue) and presentation of the simultaneous discriminanda. Following the attainment of criterion with both the simultaneous and successive discriminanda present, each monkey was retrained to criterion on each of the exponentially increasing delays (0, 1 s, 2 s, 4 s, 8 s, etc.) or until it failed to reattain criterion in 300 trials. Thus, the present study is also relevant to the study of short-term or working memory, in this case, by using a paradigm that required the use of conceptual and symbolic memory.

Method

Subjects

Four wildborn adult male squirrel monkeys (*Saimiri sciureus*) were used. All monkeys had prior experience in a Wisconsin General Test Apparatus (WGTA); however, none of the animals had been trained on the sameness–difference paradigm. Training histories included the following: Monkey T&K 1, conceptual conditional discrimination, in which oddity and nonoddity were cued by white and black test trays, respectively (Thomas & Kerr, 1976); Monkey T&C 5, "greeness" concept (Thomas & Crosby, 1977); Monkeys 79-2 and 79-5, oddity and dimension-abstracted oddity (Monkey 79-2, Thomas & Frost, 1983; Monkey 79-5, Thomas & Martin, 1980).

The monkeys were individually caged and housed in a temperature (24–27°C) and humidity (50%–70%) regulated environment. Timers controlled the onset and offset of light (0800 and 2000 hours, respectively, local time); all training and testing were conducted during the light phase. Immediately after testing, the monkeys received their daily ration of Purina High Protein Monkey Chow; water was always available. This standard diet was regularly supplemented with fresh fruits.

Apparatus, General Procedures, and Pretraining

The animals were trained in a modified WGTA. Instead of the typical one-way-mirror viewing system, our WGTA has an angled mirror mounted on the inside of the door nearest the subject. When the door is raised, the experimenter can view only the subject's responses in the mirror; this method of viewing precludes biased movements of the stimulus-presentation tray, which might occur as a result of being able to see the subject's orientation and approach to the discriminanda. A white stimulus tray, illustrated in Figure 1, was used. This tray had two food wells (2 cm in diameter, 6 mm deep, and 23 cm apart), one each located behind the outer guillotine doors. Behind the center door (9 cm wide × 13.5 cm high) was a Plexiglas cardholder in which the successive discriminandum, solid black triangle or heptagon drawn on a white index card, was presented. Behind each of the outer guillontine doors (13.5 × 13.5 cm), a pair of objects
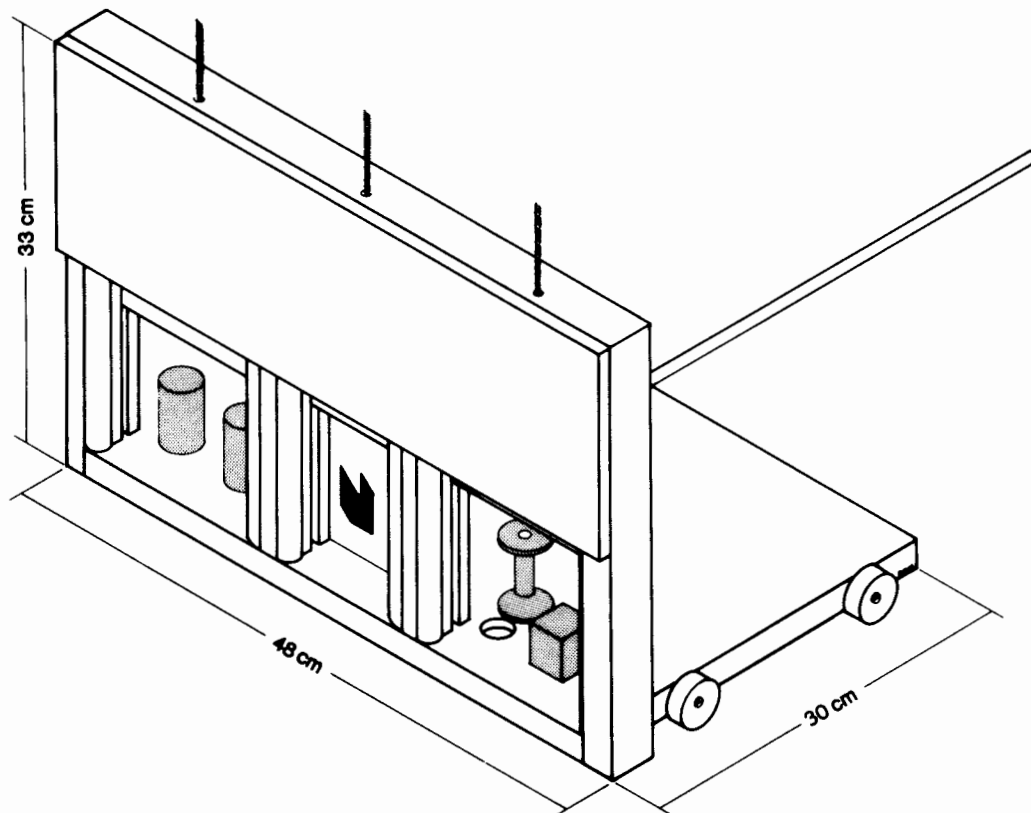
Figure 1. Stimulus–response apparatus. (In the trial shown, the heptagon in the center door is the cue that the "difference" pair of objects is correct; the left difference object is displaced to show the food well.)

(one identical pair and one pair with physical differences) could be presented. In each pair of objects, the object that was nearest the center guillotine door covered a food well (see Figure 1). The object-pairs were selected prior to each training session from the pool of discriminanda (plastic, wood, and metal toys and "junk" objects) which included a wide range of shapes, sizes, and colors. The size of the stimulus pool was increased as the study progressed, beginning with 251 objects and ending with 492 objects.

General procedures included using (a) currants as reinforcers, (b) intertrial intervals of approximately 30 s, (c) maximum allowable response times of 30 s, (d) two correction trials if necessary, and (e) a maximum of 30 trials per monkey per day. All training was conducted in the room in which the monkey was housed by moving its home cage to an empty slot in the cage rack which was adjacent to the WGTA (screens prevented the other monkeys from observing the ongoing testing). Illumination was provided by a 75-W bulb mounted in the top-center of the testing apparatus.

The initial pretraining consisted of having a monkey retrieve 10 reinforcers, 1 at a time, from the open food wells. On each trial during both pretraining and training, the food well to be baited was selected randomly according to the Fellows (1967) series. Following the retrieval of currants from open food wells, the same pairs of sameness and of difference objects were used until the monkeys retrieved (a) a total of 10 currants from food wells half covered by a sameness object and then (b) 10 currants from food wells fully covered by the sameness object.

The goal of the present research was to have the monkeys respond appropriately to both conceptual sameness and conceptual difference as determined by a conceptual and symbolic, conditional cue displayed behind the center door. Therefore, additional pretraining procedures were used to get the monkeys to (a) respond to the appropriate object within the correct discriminanda *pair* (i.e., the object covering the food well) and (b) attend to the center door of the testing apparatus. Following the initial pretraining (described in the previous paragraph), pretraining was continued by having the monkeys respond to new sameness pairs on each trial; at this time the center door was always white. This sameness pretraining was followed by difference training at which time the center door was

always black. Because the doors were only white or only black during these stages of sameness of difference training, respectively, it was not necessary for the monkey to consider the doors in its selection of the correct object. It would become necessary for the monkeys to consider the center door only when sameness-correct and difference-correct trials were presented in random order. Nevertheless, at this stage it was deemed to be desirable to have the door provide consistent cues for sameness and difference, even though such cues were not mandatory for successful performance, in the event that the monkey might become aware of the center door as a cue. Criterion performance during these stages of pretraining was 27 correct in 30 successive trials.

Training for Symbolically Cued, Conceptual Sameness–Difference Judgments

A series of eight tasks was administered. For Tasks 1–4, the symbolic cue consisted of either a specific (repeatedly presented) triangle (the cue for sameness) or a specific heptagon (the cue for difference). At this stage the symbolic cues were not necessarily conceptual. For Tasks 5–8, conceptual "triangularity" was the cue for sameness, and conceptual "heptagonality" was the cue for difference. On these problems, 1 of 120 discriminable triangles or 120 discriminable heptagons (selected randomly) appeared on each trial.[1] The stimuli (pairs of objects and symbolic cues) were changed on each trial except in the case of correction trials, and the position of the correct pair of objects was determined randomly according to the Fellows (1967) series. Correction trials consisted of presenting the same set of stimuli in the same locations once or twice. If the monkey failed on all three presentations, training was continued with the next trial and a new set of stimuli. Only the initial error from the correction series was included in subsequent data analysis, but a record was kept of the perseverative errors.

Training tasks. Task 1: In this task, the monkeys were trained to a 90% criterion (27 of 30) of correct responses to sameness, which were symbolically and *potentially* cued to a single triangle (see last paragraph of Apparatus, General Procedures, and Pretraining; the use of triangle–sameness-only here is comparable to the use of white-door–sameness there).

Task 2: This task was similar to Task 1 except that responses to difference, cued by a single, specific heptagon, were reinforced.

Task 3: This task consisted of trials such as those described in Tasks 1 and 2 being presented in random order with the restriction that an equal number of sameness and difference trials was administered in each session. As noted earlier, such random presentations of sameness and difference require the monkey's use of the center-door cue for successful performance. Criterion performance for Task 3 was 13 correct sameness responses and 13 correct difference responses in 30 successive trials.

Task 4: This task was similar to Task 3 except that time delays were introduced (initially 0, then 1, 2, 4, 8, 16 s, etc.) between the withdrawal of the

symbolic cue and the presentation of the same–different discriminanda. The symbolic cue could be seen as soon as the WGTA door facing the monkey was opened. It continued to be present for approximately 5 s; then, the door exposing the symbolic cue was closed, and after the appropriate delay, the sameness-difference stimuli were presented. Zero delay meant that the center door was closed at the same time that the side doors were raised. Training was continued, that is, the length of the delays was increased, until the animal failed to reach criterion (same as for Task 3) on a given delay in 300 trials (10 sessions).

Tasks 5–8: These tasks were similar to Tasks 1–4, respectively (i.e., 1–5, 2–6, 3–7, 4–8), except that the symbolic conditional cues were manifestations of the *concepts* of triangularity and heptagonality rather than a single, specific triangle and a single, specific heptagon.

Posttraining Control Tests

Following training on the previous tasks, the monkeys were tested to determine whether their judgments might have been based on extraneous cues rather than the appropriate cues.

First, 30 trials were administered (0 delay, see Training Task 4), with new conditional stimuli: A black circle (3.5 cm in diameter) now cued sameness, and a figure consisting of four intersecting black lines (10 cm, 7 cm, 6 cm, and 4 cm long × 0.5 cm wide) now cued difference.

Then, as a final assessment of whether the expected decrement in performance on the test described in the preceding paragraph might be attributed to a decrease in motivation or fatigue, the 0-delay portion of Training Task 4 was repeated, that is, the single, specific triangle that initially cued sameness and the single, specific heptagon that initially cued difference were again used for 30 trials.

Results

All monkeys met criterion on Tasks 1–3 (conceptual simultaneous cues but nonconceptual successive cues) and on at least some of the delays on Task 4. The maximum delay achieved on Task 4 was 16 s by Monkey T&C 5. The shortest delay achieved on Task 4 was by Monkey 79-5 which met criterion on the 2-s but not the

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[1] "Discriminable" here means that the stimuli within a class (e.g., triangles) were discriminable to the investigators. It was not determined whether they were discriminable to the monkeys. However, it has been shown that squirrel monkeys can discriminate between randomly constructed and selected heptagons and octagons (Terrell, 1983), and it seems reasonable to suggest that their ability to discriminate within a class of polygons may approximate that of the investigators.

4-s delay. Trials to criterion for all monkeys on Tasks 1–4 can be seen in Table 1.

All monkeys met criterion on Tasks 5–7 (conceptual simultaneous and successive cues) and on at least some of the delays on Task 8. The maximum delay on Task 8 was 16 s, achieved by Monkey 79-5, and the minimum delay was achieved by Monkey 79-2 on the 1-s delay. Trials to criterion for all monkeys on Tasks 5–8 can be seen in Table 2.

Although the monkeys did not reach criterion on the delay succeeding the last one on which they did reach criterion, nevertheless, they performed better than chance. It may be recalled that criterion on Tasks 4 and 8 was 13 of 15 correct (or 87%) on both the 15 sameness trials and the 15 difference trials given per session. The remainder of this paragraph presents the monkeys' *best* performances on the delay on Task 4 on which they did not meet criterion. On the 16-s delay, Monkey 79-2 had five sessions in which it was correct on 80% or more of the trials. It had a mean of 76% correct for the 10 sessions. On the 4-s delay, Monkey 79-5 had one session of 80%

Table 1

Trials to Criterion on Tasks 1–4 With Conceptual Simultaneous and Nonconceptual Successive Cues

	Monkey			
Task	79-2	79-5	T&K 1	T&C 5
1. Sameness correct	360	360	300	510
2. Difference correct	360	390	300	480
3. Sameness or difference correct	630	210	780	450
4. Sameness or difference correct with delays (in s)[a]				
0	360	300	390	210
1	30	150	90	90
2	60	300	150	210
4	30	300[b]	180	180
8	30	—	300[b]	30
16	300[b]	—	—	90
32	—	—	—	300[b]

Note: Successive cues were a specific triangle for "sameness" and a specific heptagon for "difference." The use of the successive cue did not become necessary until Tasks 3 and 4.
[a] Delays between the withdrawal of the successive cue and the presentation of the simultaneous cue. [b] Did not reach criterion.

Table 2

Trials to Criterion on Tasks 5–8 With Conceptual Simultaneous and Successive Cues

	Monkey			
Task	79-2	79-5	T&K 1	T&C 5
5. Sameness correct	420	330	360	330
6. Difference correct	180	300	420	270
7. Sameness or difference correct	450	240	360	390
8. Sameness or difference correct with delays (in s)[a]				
0	660	210	240	60
1	90	210	30	120
2	300[b]	60	60	30
4	—	30	300[b]	90
8	—	30	—	90
16	—	60	—	300[b]
32	—	300[b]	—	—

Note: Successive cues were exemplars of the concepts "triangularity" for "sameness" and "heptagonality" for "difference." The use of the successive cue did not become necessary until Tasks 5 and 6.
[a] Delays between the withdrawal of the successive cue and the presentation of the simultaneous cue. [b] Did not reach criterion.

correct and a mean of 69% correct for the 10 sessions. On the 8-s delay, Monkey T&K 1 had one session of 87% correct (and two others of 80% or better), but it did not have 87% correct for both the sameness and the difference trials; rather, it had 93% correct on the sameness trials (14/15) and 80% correct on the difference trials (12/14). It had a mean of 72% correct for the 10 sessions. Monkey T&C 5 had one session of 80% correct on the 2-s delay and a mean of 72% correct for the 10 sessions.

For the delays on Task 8 on which the monkeys did not reach criterion, Monkey 79-2 had one session of 83% correct on the 2-s delay, but the remaining sessions ranged from 70% to 77% correct, with a mean of 75% correct for the 10 sessions. On the 32-s delay, Monkey 79-5 had one session of 80% correct and an overall mean of 70% correct. On the 4-s delay, Monkey T&K 1 had two sessions of 80% correct and an overall mean of 74% correct. On the 16-s delay, Monkey T&C 5 had five sessions of 80% or better, including one of 87% correct (but 80% on sameness and 93% on difference), and had a mean of 79% correct for the 10 sessions. Finally, concerning

Tasks 4 and 8, of the 80 sessions involved (10 sessions × 4 monkeys × 2 tasks), the performance in only one session was equal to chance (50% correct). The performances in the remaining 79 sessions resulted in more than 50% correct in each. The grand mean for the 80 sessions was 73% correct.

On the sameness pretraining task, the range of trials to criterion was 300–360, with a mean of 315. The range of trials to criterion on the difference pretraining task was 330–690, with a mean of 435. On the posttraining control test, which involved 30 trials with *new* successive cues, a circle to cue sameness and intersecting lines to cue difference, and on which chance performance (7.5 correct on each type) was expected, the monkeys had means of 7 correct on the sameness trials and 4.8 correct on the difference trials. On the second posttraining control test, which consisted of a readministration of 30 trials of the 0-delay condition of Task 4, the monkeys, as expected, performed better than chance, ranging from 10 to 13 correct on both the sameness- and the difference-correct trials.

There was no consistent evidence for transfer of training from the sameness-correct pretraining task to Task 1 (in which sameness-correct was associated with the presence of a triangle) or from the difference-correct pretraining task to Task 2 (in which difference-correct was associated with the presence of a heptagon). Evidence pertinent to the preceding and following statements can be found in Tables 1 and 2. Task 3, which involved random presentations of sameness- and difference-correct trials for the first time and on which it first became *necessary* to use the successive cues, performances were varied. Monkeys 79-2 and T&K 1 showed large increases in trials to criterion on Task 3 compared with Task 2, but Monkeys 79-5 and T&C 5 showed decreases in trials to criterion on Task 3 compared with Task 2.

The introduction of the delays on Task 4 did not appear to affect performance adversely, as 3 of the monkeys took fewer trials to criterion on the 0-delay condition than they had taken on Task 3, and the fourth (Monkey 79-5) showed only a slight increase in trials to criterion. The introduc-

tion of *conceptual* successive cues on Task 5 resulted in a decline in the performances of all monkeys compared with their performances on Task 4, but their performances on Task 5 were comparable to those on Tasks 1–3.

As may be inferred from the preceding results, including Tables 1 and 2, the monkeys varied considerably in their performances across tasks, and there was scant evidence to suggest that any monkey performed consistently better or worse than any other. Overall, Monkey 79-5 tended to take fewer trials to criterion than the other monkeys and was the best monkey in terms of delays achieved on Task 8. However, it should be recalled that this was the worst monkey in terms of delays achieved on Task 4.

Discussion

Although the present study obviously is relevant to the study of short-term or working memory in animals, it is not easily related to the previous literature. In previous studies, investigators have not used exemplars of conceptual categories as stimuli either for the "initial stimuli" (ISs according to Honig & Thompson's, 1982, nomenclature instead of "successive discriminanda" as used here) or the "test stimuli" (TSs rather than "simultaneous discriminanda" here). It is not possible at this time to say whether the use of conceptual exemplars as opposed to the use of specific, repeatedly presented stimuli increases or decreases the memory burden or the difficulty of the task. It is reasonable to suggest that many animals use conceptual categories in their "real" lives (e.g., types of food items vs. specific foods, perhaps, already consumed) and that such stimuli may be as relevant to them as specific ones.

Honig and Thompson (1982) addressed the very interesting question of prospective versus retrospective memory processing. With prospective, it would be inferred that the response decision was made at the time that the ISs were in view (e.g., "triangle means to choose sameness when given the forthcoming opportunity"), whereas with retrospective, the decision is made when the TSs are presented (e.g., "sameness,

now, owing to the triangle that appeared awhile ago"). This is a difficult interpretation to make under the best of circumstances, as Honig and Thompson implied, and it should not be made here. They suggested that in the case of the delayed conditional discrimination paradigm (DCD), the response decision is made at the time of the presentation of the test stimuli (hence, retrospective processing). However, it must be noted that DCD had a different meaning for them than for us. We used the term to denote the addition of the use of delays with the traditional conditional discrimination paradigm (e.g., Borovski, cited in Lashley, 1938; and as defined by French, 1965), but for Honig and Thompson, a DCD involved only one test stimulus per trial. Our procedures are closer to what they called a delayed conditional matching paradigm.

What we can say is that at least 1 squirrel monkey was capable of remembering conceptual information for at least 16 s in order to make a conceptual choice and that others could do so with shorter delays. It is reasonable to suggest that they are probably capable of making such choices with delays longer than 16 s. There are at least three variables that could have been different and might have resulted in demonstrations of longer intervals of working memory. First, the monkeys were given only a few seconds to view the IS, and at that, we cannot be sure they attended fully to them. Second, it is reasonable to suggest that there may be more salient stimuli for squirrel monkeys than triangles, heptagons, and exemplars of sameness and difference. Third, although currants are a highly preferred food, it is reasonable to suggest that there may be more compelling reinforcers. In short, we have provided an effective demonstration that squirrel monkeys are capable of using working memory with conceptual information, but it remains to be shown just how capable they might be.

Regarding the relevance of studies such as this one to the evolution of behavior, the following points can be made. First, it is reasonable to assume that many animals, perhaps most birds and mammals, respond to exemplars of stimulus categories (i.e.,

respond conceptually) in their natural environments. It may be assumed that many animals respond to water as such, trees as such as well as to this particular water, that particular tree. Indeed, Herrnstein and his associates have shown that pigeons in the laboratory respond reliably and discriminatively to exemplars of water (pictures of puddles, streams, lakes, etc.), trees, people, leaves, and fish (Cerella, 1979; Herrnstein, Loveland, & Cable, 1976; Herrnstein & de Villiers, 1980) even when new pictures were presented. Such examples reflect the use of "natural concepts" which occur in the birds' nonlaboratory environments and to which, it may be assumed, they respond naturally.

Given that it is likely that many animals respond to many categories of stimuli conceptually and naturally, it is appropriate to inquire about their *general capacities* for conceptual behavior. To do this, it is necessary to have a scheme for classifying and organizing the kinds of conceptual behaviors there may be. Thomas (1980) adapted a scheme for use with nonhuman animals which was developed to study concept learning in humans.

According to this scheme, as adapted by Thomas (1980; based on works by Haygood & Bourne, 1965; Millward, 1971; Neisser & Weene, 1962; Turner's chapter, "Logical Atomism," 1967), there are two major categories of concepts, *class* and *relational*. These two categories are based on the elementary operations in logic. Specifically, class concepts involve affirmation and its complement, negation; relational concepts involve conjunction, disjunction, conditional, biconditional, and their respective complements. Class concepts are the "elements" of conceptual knowledge (behavior), and relational concepts are higher order concepts based on relations (conjunctive, etc.) among such elements. There are two types of class concepts, absolute and relative, as distinguished by the *necessity to compare* stimulus choices in order to affirm that an exemplar is a member of a class. To affirm that a particular tree is a member of the absolute class "tree," one need *not* compare choices, but to affirm that an exemplar is a member of the relative class "odd" or "larger," one *must compare*

choices. In terms of this scheme, the "natural concepts" discussed above are examples of absolute class concepts. Finally, the general significance of the scheme used here is that it can be argued that all conceptual behavior, no matter how complex, may be reduced to or analyzed in terms of this scheme. This argument goes back at least to Boole's work (e.g., 1854–1958), and it has been reaffirmed in a recent examination (Gregory, 1981, although he raised an interesting counterargument; see p. 229).

In the present study, four absolute class concepts were involved (triangularity, heptagonality, sameness, and difference; note, however, that more abstract examples of sameness and difference become relative class concepts; see Smith, King, Witt, & Rickel, 1975). These were used relationally, but despite the use of the term *conditional* here (which was based on its being the traditional term for the experimental procedure that was used; French, 1965), it is not possible to say whether the relation was a conjunctive (e.g., "triangle *and* sameness go together") or conditional (e.g., "*if* triangle, *then* sameness") one. To make that distinction requires tests of the truth-functional analysis of the conditional which were not done (and which may prove to be very difficult to do with nonverbal animals). Nevertheless, we can say that squirrel monkeys are capable of using relational concepts. Whether they use such concepts in their nonlaboratory lives remains to be determined, but that they have the capacity *must be* evolutionarily significant. Although stimuli such as triangles and junk objects were used here, exemplars of natural concepts might have been used. It is not too farfetched to imagine that squirrel monkeys might respond to conjunctive or conditional relations among class concepts in their natural habitats.

Although this study was not so intended, it bears on the question of linguistic abilities in animals. Savage-Rumbaugh et al. (1980) argued that an essential prerequisite for language is that animals can use "abstract symbols ... at a representational level" (p. 922). In these terms, triangularity and heptagonality were abstract symbols for sameness and difference, respectively, and they represented them over intervals in which neither symbol nor referent was present. Our study was not so relevant for language as that of Savage-Rumbaugh et al., however, because their chimpanzees were able to interpret the symbols (lexigrams for specific foods or tools) in order to, then, label them with the lexigram for the *class* "food" or "tool." Whether squirrel monkeys are capable of this type of symbolic representation remains to be investigated. Finally, Savage-Rumbaugh et al. contrasted the use of abstract symbols at a representational level with performances based on "simply learn(ing) contextually appropriate uses" (p. 922) of symbols. We suspect that they would regard our study as falling between these two interpretations.

A further point concerning the relevance of our study to the question of linguistic abilities in animals is based on Premack's (1983a, 1983b) arguments concerning successive versus simultaneous same-different judgments. He argued that the latter provide the valid measures of the same-different concept and that they are more difficult. He also indicated that language training may be essential to successful performance on simultaneous same-different tasks. The present study and an earlier one from this laboratory (Czerny & Thomas, 1975) have shown the squirrel monkey's ability to make conceptual, simultaneous same-different judgments. None of these monkeys had language training, unless, for example in the present study, their learning to associate triangularity and same, and heptagonality and different, is to be regarded as language training.

It is interesting that Premack and McClure (cited by Premack, 1983b, as being "in preparation") used a matching-to-sample task involving pairs of items (e.g., XX as sample and YY and CD as choices to be matched with the sample) and found that only their language-trained chimpanzees performed successfully. Using a similar task, Smith et al. (1975) reported that their chimpanzee "learned a generalized form of the sameness-difference matching from sample concept" (p. 471) and that the chim-

panzee had never been "previously trained on any type of learning task" (p. 469). Obviously, whether language training is important for or essential to successful same-different judgments, as Premack suggested, requires further study.

References

Boole, G. (1958). *An investigation of the laws of thought.* New York: Dover. (Originally published, 1854).

Carter, D. E., & Werner, T. J. (1978). Complex learning and information processing by pigeons: A critical analysis. *Journal of the Experimental Analysis of Behavior, 29,* 565–601.

Cerella, J. (1979). Visual classes and natural categories in the pigeon. *Journal of Experimental Psychology: Human Perception and Performance, 5,* 68–77.

Czerny, P., & Thomas, R. K. (1975). Sameness-difference judgments in *Saimiri sciureus* based on volumetric cues. *Animal Learning & Behavior, 3,* 375–379.

Fellows, B. J. (1967). Chance stimulus sequences for discrimination tasks. *Psychological Bulletin, 67,* 87–92.

French, G. M. (1965). Associative problems. In A. M. Schrier, H. F. Harlow, & F. Stollnitz (Eds.), *Behavior of nonhuman primates* (Vol. 1, pp. 167–209). New York: Academic Press.

Gregory, R. L. (1981). *Mind in science.* Cambridge: Cambridge University Press.

Haygood, R., & Bourne, L. E. (1965). Attribute and rule learning aspects of conceptual behavior. *Psychological Review, 72,* 175–195.

Herrnstein, R. J., & de Villiers, P. A. (1980). Fish as a natural category for people and pigeons. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 14, pp. 59–95). New York: Academic Press.

Herrnstein, R. J., Loveland, D. H., & Cable, C. (1976). Natural concepts in pigeons. *Journal of Experimental Psychology: Animal Behavior Processes, 2,* 285–302.

Honig, W. K., & Thompson, R. K. R. (1982). Retrospective and prospective processing in animal working memory. In G. H. Bower (Ed.), *The psychology of learning and motivation* (Vol. 16, pp. 239–283). New York: Academic Press.

Lashley, K. S. (1938). Conditional reactions in the rat. *Journal of Psychology, 6,* 311–324.

Millward, R. B. (1971). Theoretical and experimental approaches to human learning. In M. W. Kling & L. W. Riggs (Eds.), *Experimental psychology* (pp. 938–979). New York: Holt, Rinehart & Winston.

Neisser, U., & Weene, P. (1962). Hierarchies in concept attainment. *Journal of Experimental Psychology, 64,* 640–645.

Premack, D. (1983a). Animal cognition. *Annual Review of Psychology, 34,* 351–362.

Premack, D. (1983b). The codes of man and beasts. *Behavioral and Brain Sciences, 6,* 125–167. (Includes commentary)

Riopelle, A. J., & Copelan, E. J. (1954). Discrimination reversal to a sign. *Journal of Experimental Psychology, 48,* 143–145.

Savage-Rumbaugh, E. S., Rumbaugh, D. M., Smith, S. T., & Lawson, J. (1980). Reference: The linguistic essential. *Science, 210,* 922–924.

Schrier, A. M., & Thompson, C. R. (1980). Conditional discrimination learning: A critique and amplification. *Journal of the Experimental Analysis of Behavior, 33,* 291–298.

Schusterman, R. J., & Krieger, K. (1984). California sea lions are capable of semantic comprehension. *Psychological Record, 34,* 3–23.

Smith, H. J., King, J. E., Witt, E. D., & Rickel, J. E. (1975). Sameness-difference matching from sample by chimpanzees. *Bulletin of the Psychonomic Society, 6,* 469–471.

Terrell, D. F. (1983). *Conceptual discrimination of polygons by squirrel monkeys.* Unpublished master's thesis, University of Georgia.

Thomas, R. K. (1980). Evolution of intelligence: An approach to its assessment. *Brain, Behavior and Evolution, 17,* 454–472.

Thomas, R. K., & Crosby, T. N. (1977). Absolute versus relative class conceptual behavior in squirrel monkeys (*Saimiri sciureus*). *Animal Learning & Behavior, 5,* 265–271.

Thomas, R. K., & Frost, T. (1983). Oddity and dimension-abstracted oddity (DAO) in squirrel monkeys. *American Journal of Psychology, 96,* 51–64.

Thomas, R. K., & Kerr, R. S. (1976). Conceptual conditional discrimination in *Saimiri sciureus. Animal Learning & Behavior, 4,* 333–336.

Thomas, R. K., & Martin, S. (1980, June). *Oddity and dimension-abstracted oddity (DAO) in the squirrel monkey.* Paper presented at the meeting of the American Society of Primatologists, Winston-Salem, NC.

Turner, M. B. (1967). *Philosophy and the science of behavior.* New York: Appleton-Century-Crofts.